Frontiers for Science and Natural Resource Education

"We can live more fully, more pleasantly, more productively, if we try to understand the world of nature."

—Marston Bates
The Forest and the Sea

In a world in which the sprawl of development for human habitation is overwhelming the biologically diverse landscape, the national parks are oases for nature where wildlife and plant life can thrive and the physical features of the land, air, and waters can be appreciated. The parks are opportunities waiting for scientists to come and study. The National Park Service is striving to make the parks more accessible to scientists through the Natural Resource Challenge, and scientific research and collecting permit numbers are on the rise. As a result, species new to science are coming to light, the ranges of known species are being redrawn, and aspects of the physical landscape that are not easily accessible are now being examined. New technology is allowing researchers not only to investigate nature, but also to share information with the public in ways that were never before possible, as the stories in this chapter demonstrate.

approx. 0.8 inch (2 cm)

A relatively uncommon family of beetles, glowworms (*Phengodes* sp.) are closely related to fireflies. Adult females are wingless, luminescent, and look like larvae. This specimen, a male, was collected in Great Smoky Mountains National Park as part of the All Taxa Biodiversity Inventory and has been helpful in understanding the distribution of this insect group.

New ATBI species discoveries top 3,000 at Great Smokies

By Becky Nichols and Keith Langdon

THE GOAL of the All Taxa Biodiversity Inventory (ATBI) is to discover the species that occur in the 849-square-mile (2,200-sq-km) Great Smoky Mountains National Park (Tennessee and North Carolina). Sampling is to be done in such a way as to obtain distributional and abundance data and to elicit ecological information. All species, regardless of domain (i.e., Archaea, Bacteria, Eucarya) or kingdom (e.g., plant, animal), are targeted for inclusion. Furthermore, the ATBI actively involves students and other members of the public. The National Park Service and its partners in this project are hopeful that this exposure will lead to the recruitment of a new generation of scientists and nurture a science-oriented citizenry. This prototype effort is accomplished through a nonprofit partner, Discover Life In America (DLIA).

In 2003, ATBI activities continued to gear up—a "beetle blitz" attracted coleopterists from across the United States in June, and multiple taxonomic working groups (called TWiGs) benefited from a "high county quest" in July. Additionally, the ATBI has developed a new relationship with the National Biodiversity Information Infrastructure (NBII) node for the Southern Appalachians, resulting in a significant upgrade of the ATBI website (www.dlia.org) and data management functions. Participating scientists received $400,000 in funding from the National Science Foundation (NSF) to complete the algae portion of the ATBI, and slime mold researchers obtained a $2 million NSF Planetary Biodiversity award for a global study that will include Great Smoky Mountains National Park. Annual operations for this project are mostly dependent on funding from the Friends of the Smokies and the Great Smoky Mountains Association. (The ATBI is not funded by the Natural Resource Challenge or Natural Resource Preservation Program.)

"The ATBI is not funded by the Natural Resource Challenge or Natural Resource Preservation Program."

At the annual conference in December, Dr. Peter Raven, the world-renowned botanist and an advocate of biodiversity conservation, delivered the keynote address. He stressed the need for more efforts like the ATBI. The idea may be catching on, as representatives from other parks and reserves took part in a pre-conference session to learn how to undertake intensive biodiversity inventories.

By December 1, 2003, a total of 410 species new to science had been discovered. An additional 2,955 species constituted new records for the park, bringing the total of new discoveries to 3,365. ■

The adult male dobsonfly (*Corydalus cornutus*), also collected as part of the All Taxa Biodiversity Inventory, looks as if it can inflict a painful bite, but actually does not have the strength to do so. The larvae of this species, called hellgrammites, occur in a wide variety of aquatic habitats and are predaceous; adults are terrestrial.

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Rocky intertidal monitoring partnerships aid management at Cabrillo National Monument

By Bonnie J. Becker

CABRILLO NATIONAL MONUMENT (California) administers a small (120-acre, 49-ha) but very well-protected tidepool area adjacent to the mouth of San Diego Bay. The educational, recreational, and spiritual opportunities afforded by this place are directly dependent on the park's ability to effectively manage marine resources, which in turn depends on access to accurate information on the state of those resources. For 13 years park staff and an army of volunteers have been monitoring 13 key marine species that serve as indicators of the ecological condition of this rocky shoreline. In 2003 the interpretive power of the monitoring data has been greatly strengthened through partnerships, allowing park staff to draw conclusions about the success of management in the park and the region.

This monitoring program, in addition to a number of similar programs in the region, was adapted from techniques used at Channel Islands National Park. In 1997 these programs joined to form MARINe, the MultiAgency Rocky Intertidal Network, an association of 23 academic, private, federal, and local agencies (www.marine.gov), representing 57 sites in six California counties. MARINe is administered by the Minerals Management Service and is dedicated to standardizing the techniques used to monitor the rocky shoreline of southern California and compiling the resulting data. In 2003, MARINe completed the onerous task of forming a centralized database, allowing the first regional view of intertidal systems.

Through this partnership, data collected at Cabrillo can be put into a larger context. Park staff has been documenting the sizes of the giant owl limpet, a primitive snail related to the valued and threatened abalone. Dr. Jack Engle (University of California [UC] Santa Barbara) is monitoring limpets at four MARINe sites, 2 to 20 miles (3.2 to 32 km) north of Cabrillo, with funding from the U.S. Navy. Limpets at these sites are minimally protected from harvesting. Harvesting as a food item leads to removal of the largest individuals from the population. This difference is reflected in the data: the average Cabrillo limpet was more than 40% bigger than at the nearby sites.

"Four species of snails, including the owl limpet, are significantly larger at Cabrillo than at any other site in the Southern California Bight."

In 2003, Dr. Kaustav Roy (UC San Diego), Engle, and park staff published a study demonstrating that this effect is widespread (*Ecology Letters* [2003] 6:205–211). Four species of snails, including the owl limpet, are significantly larger at Cabrillo than at any other site in the Southern California Bight. Museum samples and living specimens from the area were measured, revealing that the current snails are much smaller than samples collected before 1960, when the human population was much lower. However, Cabrillo snails are the same size as or larger than they were before 1960, and are much larger than in the years after 1960. Larger individuals are usually much more fecund

One of 13 marine species monitored at Cabrillo National Monument, giant owl limpets (page 51) are significantly larger in the park's protected tidepools than in nearby areas that are minimally protected. Research findings published in 2003 link the larger size of several marine organisms in park tidepools, a resource enjoyed and appreciated by local and visiting tourists alike, to the park's protection strategies.

than smaller ones. Additionally, selectively removing large limpets leads to a gender imbalance; all are born males that become females as they grow. Both of these circumstances lead to decreased reproduction.

For many people a visit to Cabrillo represents one of the few interactions they will ever have with marine life, and the quality of that experience is related to the condition of the resource. The Cabrillo tidepools are well-known for their quality and are preferred by both locals and visiting tourists over nearby tidepools where harvesting is allowed or limitations are not enforced. Visitation to the park is extremely high; up to 384 visitors have been counted in a single hour.

"The Cabrillo tidepools are well-known for their quality and are preferred by both locals and visiting tourists over nearby tidepools where harvesting is allowed or limitations are not enforced."

The poaching impacts of visitation are limited by park management strategies, including the presence of education and enforcement volunteers. A Tidepool Protection, Education, and Restoration Program was established whereby volunteers explain the natural components of tidepools, how to enjoy them without harming them, and ongoing research programs.

As a result of research findings, a no-access area was established in 1996 that serves to protect existing populations as a source of organisms to adjacent areas and as an undisturbed control for many studies. Two visitor surveys were conducted by an outdoor recreation policy class at San Diego State University in 1997 and 2001. These indicated strong support (99%) by the public, who "approve of closing part of the tidepools to allow it to recover."

Giant owl limpet, Cabrillo National Monument

Although Cabrillo National Monument administers only a small part of the southern California coastline, it plays an important role for its wildlife, visitors, and the region. It is an enclave of protection for limpets and many other invertebrates from the rapid pace of urbanization in the region. The offspring of the protected Cabrillo populations will spill over park boundaries through ocean currents to enhance other populations in the region. The park's approaches and policies help ensure that the tidepools of Cabrillo will continue to provide protection to the resource, increased marine populations in the region, and meaningful visitor experiences for future generations. ■

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award-winner

Dr. David Cole a pioneer in the field of recreation ecology research

David Cole, a research biologist stationed at the Aldo Leopold Wilderness Research Institute in Missoula, Montana, has received the 2002 Director's Award for Natural Resources Research. He is employed by the USDA Forest Service but his research in recreation ecology transcends agency boundaries and is particularly important to National Park Service managers because it provides them with a framework for dealing with recreational carrying capacity issues. Dave brings a scientific mindset to the problem of balancing visitor use with minimal damage to the environment and emphasizes the importance of formally defining problems and setting quantifiable objectives. One of his major research efforts is to understand the relationship between amount of use and amount of impact in different ecosystems. His studies indicate that in many situations "relatively low levels of use cause near-maximum impact, so as use increases, impact does not increase very much." This has major implications, for example, for the appropriateness of campsite policies. Furthermore, he has shown that where low levels of use have caused impact, existing impacts are often extremely slow to recover even if use is greatly reduced.

"His research in recreation ecology transcends agency boundaries."

Through publications, presentations, and workshops David has assisted wilderness managers in developing policy in light of scientific research. His contribution to the Leave No Trace program was to refine practices by basing them on such research. For example, visitors had been urged not to walk in meadows because meadow was thought to be more fragile than forest. Dave's research found that although damage to meadows is more unsightly than impacts in the forest, meadows are actually more resistant than forest ecologies.

Dave started out as a geographer. His dissertation was about wilderness vegetation and he decided to focus on the impact of humans on wilderness. He says, "Nobody else had made a career of that subject, so that's given me lots of opportunities." ■

Invertebrate biodiversity in hemlock forest studied

By Betsie Blumberg

AT SHENANDOAH NATIONAL PARK (Virginia), stands of hemlock forest are distinctive habitat for many species of invertebrates. Unfortunately the hemlock forests at the park and throughout the mid-Atlantic are threatened by an exotic insect pest, the hemlock wooly adelgid (*Adeleges tsugae*). To assess the invertebrate biodiversity of hemlock forests, a study was undertaken at the park by a multidisciplinary team of researchers from the Pennsylvania State University. Specimens were collected in August 1997 at two forest stands: Limberlost, a hemlock forest, and, for comparison, Mathews Arm, a hardwood forest. The specimens were identified and prepared at the Frost Entomological Museum at the Pennsylvania State University and the project report, "Biodiversity Associated with Eastern Hemlock Forests: Assessment and Classification of Invertebrate Biodiversity," was completed this year.

This study of 13,169 invertebrate specimens produced new records and documented 10 species that are potentially new to science. The discovery of new species was anticipated because scientists believe that less than 50% of North American insect and arachnid species are known. Findings in the two stands were compared using biodiversity profiles and guild analysis (sorting species based on feeding behavior). The study revealed that several orders of invertebrates contained families and species that seem to be unique to hemlock forests.

The report produced a number of management recommendations for future research. Among them was an emphasis on the importance of developing biodiversity inventories for specific habitats and

"This study of 13,169 invertebrate specimens produced new records and documented 10 species that are potentially new to science."

ecosystems before the outbreak of a stressor such as the hemlock wooly adelgid. Because a stressor of this type can change the structure of an ecosystem and affect biodiversity, inventories conducted after the infestation can indicate the process of biodiversity turnover and measure the impact of the infestation.

Understanding the biodiversity of the hemlock forest habitat yields insight into the devastation resulting from the hemlock wooly adelgid infestation; with the loss of the trees comes the loss of the special ecosystem they foster. ■

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The white, cottony material on the back of this hemlock twig (top) reveals an infestation of the hemlock wooly adelgid and foretells destruction of hemlock forests at Shenandoah National Park (bottom). A recent survey of invertebrates indicates that not only are the hemlocks threatened but so are many species that occupy the special habitat they create.

NPSFACT

The National Park Service began tracking the number of new scientific research and collecting **permits issued annually** throughout the National Park System in 2001 when 2,231 such permits were issued.* This number **increased to 2,367 in calendar year 2002** and 2,501 in 2003.

**Permits are required for scientific research activities that involve natural resource or social science fieldwork and specimen collecting of biological, geological, and paleontological resources. Activities such as birding and noncommercial photography are not regulated by permit; some official research and collecting conducted by NPS staff require a permit. Other permit procedures apply to scientific activities pertaining solely to cultural resources.*

Virgin Islands monuments move forward

By Cliff McCreedy

ON FEBRUARY 27, 2003, Secretary of the Interior Gale A. Norton announced that regulations to protect the new Virgin Islands Coral Reef National Monument and the expanded Buck Island Reef National Monument will go forward. Her statement at the U.S. Coral Reef Task Force meeting in Washington, D.C., marked a critical change in management and protection of coral reefs in the Virgin Islands parks. The new monuments were created in 2001 to restore these coral reef ecosystems and replenish fish and shellfish populations. Designed to be managed as fully protected marine reserves, the monuments finally became effective with Secretary Norton's announcement and promulgation of regulations in May 2003.

"Years of tenacious scientific work and careful legal and policy research culminated in the long-overdue realization of these promising new reserves."

"The conservation of our coral reefs is a high priority at the Interior Department," Secretary Norton said. "These 'rain forests of the sea' are not only breathtaking but they are also storehouses of immense biological wealth. We will be protecting them against damage by careless boat anchoring and all extractive uses except some traditional fishing."

The new 12,708-acre (5,147-ha) Virgin Islands Coral Reef National Monument was established to increase protection of marine resources located near the Virgin Islands National Park on St. John, while the Buck Island Reef National Monument on St. Croix was expanded from 880 acres (356 ha) to more than 19,000 acres (7,695 ha). The Buck Island expansion area includes additional coral reefs (patch, spur and groove, deep and wall) and the unusual "haystacks" of elkhorn coral that support endangered sea turtles and a high diversity of marine life and that attract tour boats to the snorkel trail. The Virgin Islands Coral Reef National Monument has both bank and spur-and-groove reef formations, mangrove shorelines, hardbottom habitat, and seagrass beds. Recreational boating, snorkeling, and scuba-diving are encouraged, but anchoring requires a permit at Buck Island Reef and is not allowed at Virgin Islands Coral Reef National Monument. Fishing for blue runner and baitfish in limited portions of Virgin Islands Coral Reef National Monument is the only form of fishing allowed.

Years of tenacious scientific work and careful legal and policy research culminated in the long-overdue realization of these promising

Massive branches characterize elkhorn coral (*Acropora palmata*), an ecologically important marine species in national parks of the Caribbean Sea. Created in 2001, the new Virgin Islands Coral Reef National Monument and the expanded Buck Island Reef National Monument will help restore coral reef ecosystems and replenish fish and shellfish populations.

new reserves. That fish, lobster, and conch populations had diminished to alarming levels was not in doubt. Studies by park staff and U.S. Geological Survey (USGS) scientists had contributed greatly to understanding how fishery resources and reef fish assemblages had declined dramatically from overfishing, illegal harvest, and ongoing mortality from discarded fish nets and traps. Two recent joint studies by Dr. Caroline Rogers of the USGS and Dr. Jim Beets of Jacksonville University identified low biomass and low numbers of species and individuals of finfish and shellfish. Ironically, Rogers and Beets reached the conclusion that species composition and numbers of fish, lobsters, and conch are no greater inside Virgin Islands National Park, where one would expect greater species protection, than outside park boundaries.

Scientific collaborations and interagency partnerships will continue to be critically important to park managers in evaluating the efficacy and performance of the recently created reserves. For example, Buck Island Reef and scientists with the National Oceanic and Atmospheric Administration's (NOAA) National Center for Coastal and Ocean Science Biogeography Program have been collaborating since January 1999 to map and document benthic habitats and marine species in the existing and expanded Buck Island Reef area. They will intensify their work, using a NOAA research vessel (March 2004), equipment, and scientists, with additional funding from the NPS Natural Resource Preservation Program beginning in FY 2005. Virgin Islands Coral Reef National Monument plans similar surveys of fish and invertebrate populations. These efforts will evaluate coral health, document previously harvested species of fish and marine invertebrates, and shed light on their possible recovery in the reserves.

All the Virgin Islands parks are highly popular destinations for tourists to enjoy beautiful landscapes above and below water. Each is developing general management plans (GMPs) beginning in 2004. Development of GMPs and outreach and education will be critical to designing the shared future of these parks in collaboration with fishers, local communities, the tourism industry, and the Virgin Islands territorial government. ■

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National park research engages future scientists participating in *JASON XIV: From Shore to Sea*

By Yvonne Menard

STUDENTS FROM AROUND THE WORLD went on a virtual science expedition to the California Channel Islands in 2003 with world-renowned oceanographer and explorer Dr. Robert Ballard. Known as *JASON XIV: From Shore to Sea*, the year-long study adventure highlighted research and science at Channel Islands National Park and National Marine Sanctuary, and more than 1.6 million middle and elementary school students and 35,000 teachers participated.

Ballard started the JASON Project in 1989 after receiving more than 16,000 requests from students who asked to go with him on his next expedition following the RMS *Titanic* discovery. The JASON Project, designed to engage students in science and technology, has been proven to motivate them to take a greater interest in scientific careers. Its multimedia components include a standards-based curriculum, interactive live satellite broadcasts, hands-on field research, professional development for teachers, classroom exercises, and an award-winning website.

During *JASON XIV*, students used cutting-edge technology to discover the marine and terrestrial ecosystems, geology, archeology, and cultural history of the Channel Islands. The national park became a living laboratory, a setting to stimulate young minds, a place to engage in research.

Students from around the globe interacted via a two-way satellite link with researchers on Anacapa Island and at the Santa Barbara Maritime Museum. During two weeks in December and January they participated in more than 55 live satellite broadcasts, at least one of which was aired daily on the National Geographic Channel. Through the broadcasts students in the classroom had the opportunity to monitor urchins in the kelp forest, study a recovering island ecosystem, and immerse in the traditions of the native Chumash.

Addressing JASON Argonauts worldwide, guest researcher Jean-Michel Cousteau recounts the technological advances in diving equipment that have allowed scientists to gain a better understanding of ocean resources and direct conservation efforts.

Broadcasting live, *JASON XIV* host and oceanographer Dr. Robert Ballard and his Argonaut cohost (top) facilitate interaction of students around the world and researchers in the field at Channel Islands National Park and the Santa Barbara Maritime Museum. During a two-week period, the JASON Argonauts, alongside researchers, explored underwater kelp forests at the park, immersed in native Chumash culture, reviewed the history of diving, and applied remote sensing tools to ecological monitoring on Anacapa Island.

Designed to engage students in science and technology, the JASON Project modeled its field activities in 2002/2003 after actual resource monitoring being conducted at Channel Islands National Park. In one exercise Argonauts (above) compared real-time ocean temperature data relayed from a radio-controlled NASA airplane with those collected by divers at the park and satellites. Rich in biodiversity, kelp forests thrive in cool water and are monitored at the national park.

Assisting Dr. Ballard, a select group of students, teachers, and researchers hosted the broadcast via satellite and the Internet. Alongside researchers, these student Argonauts answered questions on Web chats and posted daily journals. They were the first to test a brand-new Uninhabited Aerial Vehicle (UAV), created for the JASON Project by NASA's Goddard Space Flight Center. The Argonauts compared and analyzed data collected by the UAV, space satellites, and underwater instruments. The UAVs were outfitted with a thermo-infrared imager, which measured heat output and translated it into black and white images, allowing students to detect changes in sea surface temperatures or survey the kelp beds and sea lion rookeries.

Alongside national park marine biologist David Kushner, students monitored the health of subtidal species and debated the reasons for establishing marine reserves. Stimulated by the efforts of park terrestrial biologist Tim Coonan to save the endangered island fox, teams of students used a Web-based ecology simulation game to develop their own fox recovery plan.

This project was created and supported by a phenomenal partnership among the JASON Foundation for Education, Channel Islands National Park and National Marine Sanctuary, NASA, the Santa Barbara Maritime and Natural History Museums, the University of California, and Ventura and Santa Barbara County schools. A National Park Foundation grant sponsored more than 70 local teachers and their students, providing them with the JASON curriculum. These local schools continue to develop innovative ways to use the content-rich *JASON XIV* curriculum. The JASON Project has become the backbone of one school's Gifted and Talented Education program. Another school offers *JASON XIV* as an elective science course. An evaluation conducted by the Educational Development Center for Children and Technology found that the teaching methods used by the JASON Project increased students' abilities to understand scientific concepts and manipulate data, improving critical thinking and communication skills.

"Students in the classroom had the opportunity to monitor urchins in the kelp forest, study a recovering island ecosystem, and immerse in the traditions of the native Chumash."

The national park environment gave these budding scientists a chance to step out of the classroom and into an outdoor lab, an opportunity to explore the natural world. In the words of Tano Cabugos, a 13-year-old Argonaut of Chumash descent, "I want to help the ocean, and the more I can learn … the better I can help." After scuba-diving in the island kelp forest, Tano said, "Everything is so alive and every movement you make affects everything around you. Since I was four, I wanted to be a marine biologist. That dive was just incredible. Underwater, I felt like I was in outer space, just so aware of my body and the whole world around me. I can't wait to get down there and explore." ■

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Distance learning and a prescribed burn at Homestead National Monument of America

By Amy Garrett

LONG-DISTANCE PHONE CALLS used to be the next best thing to being there. In 2003, long-distance learning technology created an experience just like being there. For example, students from two Nebraska high schools connected with on-site professionals at Homestead National Monument of America in Beatrice, Nebraska, during the annual prairie burn in May 2003. The real-time, curriculum-based education program at Homestead is a model for how distance learning can be integrated into a park's interpretation and education programs.

As the prescribed fire burned in the background, students conversed with wildland firefighter and natural resource management specialist Jesse Bolli as he discussed fire ecology, the tools of wildland firefighting, and the beneficial effects of fire on the tallgrass prairie. Interacting with knowledgeable professionals on the scene, like Bolli and Jim Loach, associate regional director of the Midwest Regional Office, makes this distance-learning experience exceptionally rewarding for students. As events unfold on the prairie, students ask questions that stimulate discussion. This method—made possible through a partnership with the Southeast Nebraska Distance Learning Consortium and Educational Services Unit 5—provides a learning opportunity for students that they otherwise would not have.

"Students and NPS staffs were part of the action but in the safety and convenience of their classrooms and offices."

Amy Garrett, education coordinator for Homestead National Monument of America, controls the operation of the distance-learning cart while Jim Loach, associate regional director, and Jesse Bolli, firefighter and resource manager, discuss the prescribed burn and answer students' questions. Garrett exclaimed, "We're only limited by our imaginations on how we use this technology."

Students remotely viewed firefighters using hoses and drip torches during the annual prairie burn at Homestead. Long-distance technology is an "exciting tool," remarked Mark Engler, superintendent of the national monument. "Many times people like to get into the thick of the action. This allows students to experience that while in the safety of their classrooms."

The monument maintains a four-year, prescribed-burn cycle that simulates the historical fire regime. Each year a third of the tallgrass prairie is burned on a rotational basis; every fourth year no burn is ignited. Historically, lightning strikes have started fires on the tallgrass prairie, and Native Americans introduced fire to bring bison herds back to graze on grass. They also used fire in warfare and protected their villages by burning firebreaks around them.

During the burn, students were afforded panoramic views of the prairie via the distance-learning cart, which is equipped with a computer and cameras. The cart is connected to a power source and fiber optics. The power and fiber-optic connections are hidden under four artificial boulders located around the visitor center. For the last couple of years park and public educators have used this distance-learning program to explore various uses of the equipment to better serve students and to support required educational standards. Moreover, through NPS Parks As Classrooms grants, the monument has acquired additional tools for use with the new distance-learning technology. For example, calculator-based labs, graphing calculators, and global positioning systems enhance resource-based learning activities. In addition to prescribed burns, these tools are used to monitor water quality, track erosion of the monument's Cub Creek, and explore tallgrass prairie biota such as insects and animals.

While students interacted through distance-learning technology, Midwest Region staff members saw the event take place over the Internet via video-streaming equipment. Those viewing the burn over the Internet were not able to interact with the rangers, but they witnessed the prescribed burn in real time. Hence, students and NPS staffs were part of the action but in the safety and convenience of their classrooms and offices. ■

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Improving the "Geology Talk"

By Jim F. Wood

NATIONAL PARKS house the icons of America's geologic heritage, comprising what is arguably the world's greatest educational rock collection, but geology can be a difficult subject to present to the public. In March 2003 a two-day workshop was held at the National Science Teachers Association conference in Philadelphia to help participants from 25 parks and several central offices improve their skills and knowledge in communicating geologic stories and issues.

The topics covered in the workshop included planning for natural resource issue interpretation, making geology relevant, using geologic themes, the nature of science, and controversial issues in geoscience. All workshop participants shared examples of projects from their parks and several invited speakers gave special presentations.

Bob Lillie, National Park Service seasonal interpreter and professor at Oregon State University, gave an overview of national park geology using regional geologic setting and modern landform analogies to make park geology more understandable. Phil Zichterman, chief of interpretation, education, and technology at Curecanti National Recreation Area, demonstrated new low-cost technology that parks can use to create quality video for educational projects on the Web or on a DVD player. Allyson Mathis, interpreter at Grand Canyon National Park, presented a suite of interpretive techniques for geology programs and led discussions on the nature of science and controversial issues for frontline interpreters.

"Geology can be a difficult subject to present to the public."

Workshop participants also learned about "Views of the National Parks" from Dave Krueger, information technology specialist with the Natural Resource Information Division. An interactive, educational computer application, Views presents general information and scientific principles on Web pages and CD-ROMs (see www2.nature.nps.gov/synthesis/views). Geology-related themes designed in the past year include volcanism, glaciers, paleontology, and coastal geology. Thematic geology modules prepared in Views become building blocks that any park can use as a starting point to tell its own unique geologic story.

Views takes the user to a park through multimedia presentations and interactive educational units that help to ensure that park programs reach a greater number of people, including those who are unable to visit park sites or attend a ranger-led program. Geology-related virtual experiences have been prepared for Pu'uhonua o Honaunau National Historic Park (Hawaii) and Timpanogos Cave National Monument (Utah). Several others are being prepared, including Florissant Fossil Beds (Colorado) fossil mysteries, Grand Canyon (Arizona) river-to-rim geology, and geology on the National Mall (Washington, D.C.).

A core concept for the workshop was the four-step method for planning and evaluating natural resource issue interpretation, as described in the 1995 National Park Service report "Interpreting Critical Natural Resource Issues in Canadian and United States National Park Service Areas." These steps include identifying the issue, determining the message, targeting the message, and determining techniques. Report author Mike Whatley, chief of the Natural Resource Information Services Branch, led the group in activities using the four-step method to evaluate existing programs and frame new proposals.

Interpreting geology to national park audiences is a specialized skill. In March, NPS staff participated in a two-day workshop to improve their abilities and knowledge in communicating geologic stories and issues.

By conducting the workshop in conjunction with the National Science Teachers Association conference, National Park Service interpreters had the opportunity to attend the larger meeting, exposing them to a number of useful educational techniques, inexpensive sources and supplies, and a network of teacher contacts.

The Geologic Resources Division, the Natural Resource Information Division, and workshop presenters are developing a manual on communicating geologic stories and an issues handbook to deliver the information to those who could not attend the workshop. The Natural Resource Information Division also plans to use the geology workshop as a model for future workshops on natural resource topics. ■

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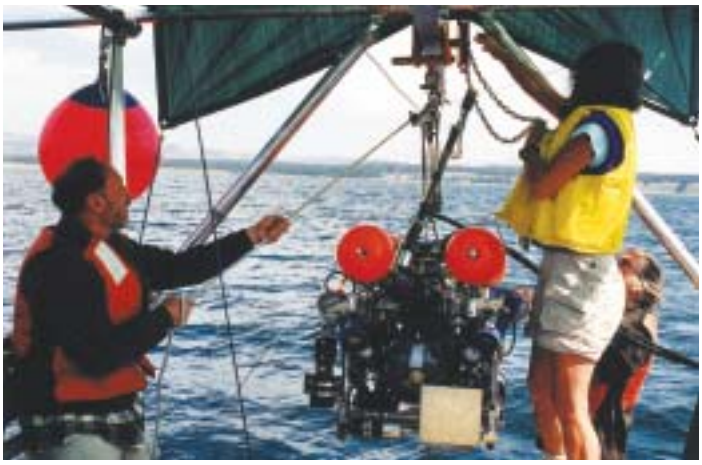
New discoveries on Yellowstone Lake's floor

By Alice Wondrak Biel with Lisa Morgan

BELOW THE WATERS of Yellowstone Lake (Wyoming), researchers have identified a spectrum of fascinating geologic features. The five-year (1999–2003) cooperative effort between the U.S. Geological Survey (USGS) and the National Park Service has resulted in a high-resolution map of the floor of Yellowstone Lake, revealing many features not recognized in previous lower-resolution maps.

Using high-resolution multibeam swath sonar imaging, seismic reflection sub-bottom profiling, and a submersible remotely operated vehicle, researchers discovered submerged faults, explosion craters, domal features, siliceous spires, hydrothermal vents, submerged paleo-shorelines, and slumped structures. Also found were rhyolitic lava flows that extend far out into the lake that are believed to be a key to controlling many morphologic and hydrothermal features in the northern two-thirds of the lake. The team produced the first geologic map of Yellowstone Lake that accurately depicts the Yellowstone caldera boundary where it passes through the lake. In short, where relief maps of the park once showed Yellowstone Lake simply as a flat blue spot in the middle of detailed topographic features, now the lake is seen as a multifeatured, topographic space. Moreover, results are providing insight into the extent of post-caldera-collapse volcanism, glaciation, active hydrothermal processes, and potential geologic hazards.



Dave Lovalvo (left), of Eastern Oceanics, along with Lisa Morgan (center) and Pat Shanks (right) of the USGS, launches a remotely operated vehicle (ROV) into Yellowstone Lake. The ROV allows direct observation and sampling of features identified in the bathymetric surveys of the lake floor.

In 2003 the research team, composed of members from the USGS and Eastern Oceanics, collected seismic reflection profiles in the Southeast, South, and Flat Mountain Arms and other areas of the lake, including hydrothermal areas. Unlike multibeam swath sonar imaging, which maps the surface of the lake floor, seismic reflection profiling penetrated the lake floor to about 80 feet (25 m), giving researchers detailed information about the physical character of the subsurface. Using a submersible, the team spent an additional five days photographing lake-floor features and sampling vent fluids and solids. The research team, joined by scientists from the University of Minnesota, also deployed a newly developed, in situ chemical sensor capable of measuring pH, temperature, and concentrations of hydrogen sulfide and hydrogen. The sensor provides information in real time about short-term variations in the composition of hydrothermal vent fluids.

"Results are providing insight into the extent of post-caldera-collapse volcanism, glaciation, active hydrothermal processes, and potential geologic hazards."

Park wildlife managers also are benefiting from these revolutionary mapping efforts. In summer 2003, research focused on areas known to be spawning habitat for nonnative, fish-eating lake trout. By understanding the seismic character of these areas, park managers hope that unknown spawning sites for this aggressive species will be identified, enabling fisheries scientists to better manage lake resources. Additionally, researchers have investigated hydrothermal vent fluids on the lake floor and the possible transmission of potentially toxic trace metals, including mercury, antimony, arsenic, and thallium, from vent fluids up through the food chain to native Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) and animals that feed on them. Examination of the mercury content of some fish revealed slightly higher concentrations than for most fish in western lakes. In addition, hair samples collected by the Interagency Grizzly Bear Study Team from two bears living near the lake showed elevated levels of mercury, whereas two bears elsewhere in the park did not. Moreover, cutthroat trout frequent shallow hydrothermal vent areas in the lake, sometimes called "trout jacuzzis." Hence, a picture of geochemistry and its effects on the ecosystem in Yellowstone is emerging.

The lake-mapping effort was one of eight interdisciplinary tasks that USGS scientists recently completed under the Integrated Geoscience Studies of the Greater Yellowstone Area Project. An 18-chapter USGS professional paper and maps summarizing the findings from this work are in press. Available publications are listed at http://minerals.cr.usgs.gov/projects/yellowstone/products.html#task7. ■

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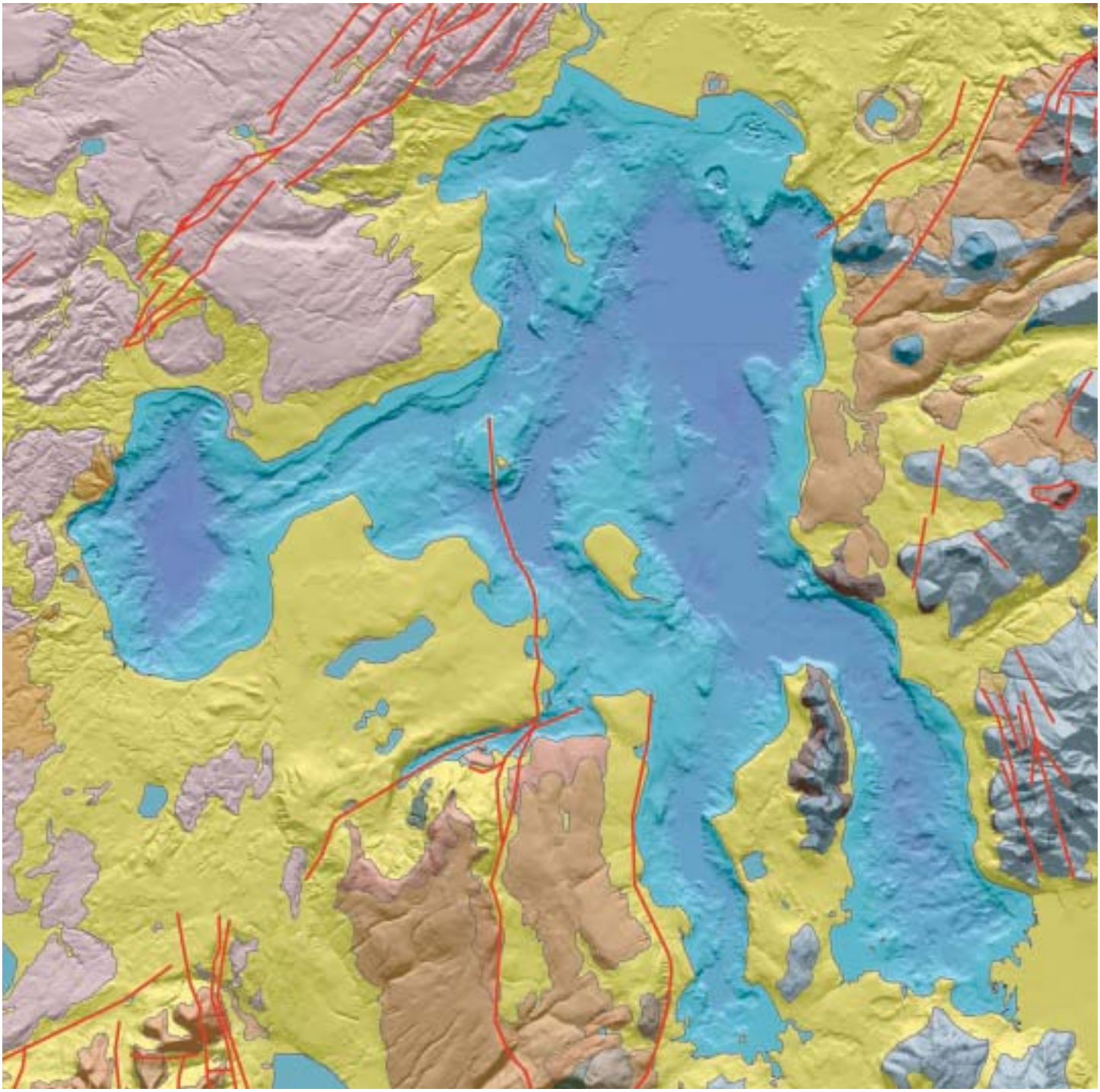
HIGH-RESOLUTION BATHYMETRIC RELIEF MAP OF YELLOWSTONE LAKE



This high-resolution bathymetric relief map of Yellowstone Lake (blue areas), acquired by multibeam sonar surveying, depicts hydrothermal vents, faults, explosion craters, and many other features. Researchers from the USGS, in partnership with the National Park Service, discovered the features while mapping the lake floor over the past five years. The colorful shapes surrounding the lake represent different geologic units. Red lines are faults.